Bell Work
17-Jan-17

How are group number *and* number of valence electrons related?

Agenda

Lewis Dot Structure – Atoms (recap), Compounds
Steps 1-4

Objective:
You will KNOW how to draw Lewis Structures of simple common compounds and ions

EQ: What am I doing today for my future goals and how can keep on track.

Bell Work, 18-Jan-17

Using only the periodic table:

A. List the number of each atom in H_2S

B. How many valence electrons (Ve^-) does a Hydrogen have?

C. Ve^- Sulfur:

D. What is the total number of Ve^- dihydrogen sulfide has?

Agenda:

Valence electron (Ve^-)

Drawing Lewis structure

Objective: You are going to be able to determine the total number of valance electrons in a molecule and be able to apply the octet rule in drawing Lewis structure

EQ: What am I doing today for my future goals and how can keep on track.

Lewis Structure Overview

https://youtu.be/1ZlnzyHahvo

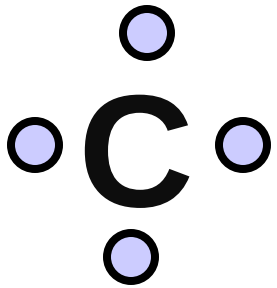
Drawing Lewis Structures

We learned how to draw Lewis Dot structures of ions a few months ago.

To draw a Lewis dot structure of an ion simply draw the elements symbol and then distribute electrons around the symbol.

Take Carbon:

Total # of valence e^- (equals group #): 4



You try: F, O, Mg

You have 30 sec.

Drawing Lewis Structures

Lewis structures are used to identify the types of bonds (single —, double =, triple ≡) formed between atoms in a molecule or polyatomic ion.

Drawing the Lewis structure is not difficult ☺
IF you follow the exact process that I give you.

Now for the steps…

Drawing Lewis Structures

1. Add up the valence electrons from all atoms

H_2O Ve^- :

1 from each H & 6 from O

So 2(1) + 1(6) =8

CO_2 Ve^-:

4 from C & 6 from each O

So 1(4) + 2(6) = 16

You try: SO_2 and SiO_2

SO_2 Ve^- = 1(6) + 2(6) = 18

SiO_2 Ve^- = 1(4) + 2(6) = 16

Drawing Lewis Structures

1. Add up the valence electrons from all atoms

For a cation (+), subtract 1 electron for each positive charge

NH_4^+ : 1(5) + 4 (1) -1 = 8 Ve^-

For an anion (-), add 1 electron for each negative charge

CN^- : 1(4) + 1(5) + 1 = 10 Ve^-

You try: NO_2^-, CO_3^{2+}

NO_2^- Ve^- = 1(5) + 2(6) + 1 = 18

CO_3^{2+} Ve^- = 1(4) + 3(6) -2 = 20

Drawing Lewis Structures

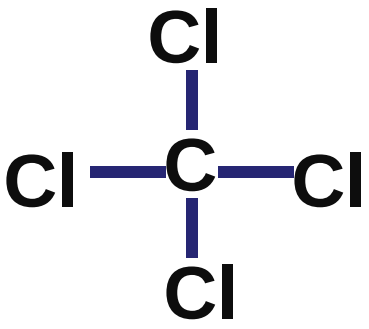
2. Draw a skeleton structure showing the chemical symbols for each atom. Connect the appropriate atoms using a single bond –, each line represent 2 e-.

Sometimes (but not always) the order in which the formula is written

HCN: H-C-N

Central atom (written first) surrou atoms

CCl_4 :



Drawing Lewis Structures

3. Add electron pairs, ∞,to the atoms bonded to the central atom first until each has an octet (8) of e^-.

Remember, H only gets $2e^-$ so once it bonds it has its $2e^-$.

H – Cl

IF there are any unused e^-, *<u>place all of the leftovers on the central atom</u>*.

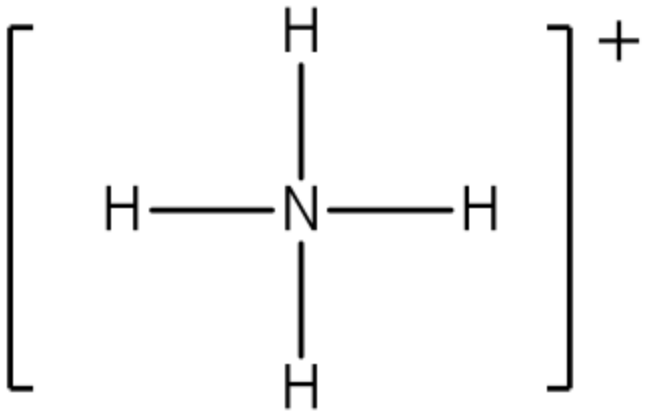
Note: This sometimes gives the central atom more than eight e^-.

Drawing Lewis Structures

4. Do all atoms that need an octet have one?
Did you use all of the valance electrons?

If you answered yes then you are done.

Note: if you are drawing an ion (charged particle) the you must put the structure in brackets and label the charge NH_4^+



Practice

Complete the following for Br_2

#of Valence electrons :_____

# of lone pairs (electrons ••):_____

#of bonding pairs (—): _____

Structure:

Br Br

Drawing Lewis Structures

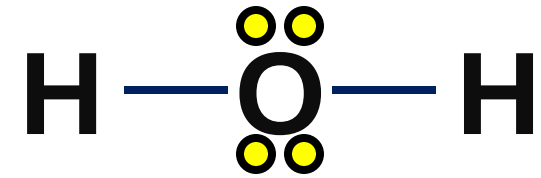
- **Lets try one: H_2O**

Number of Ve^- : **$2(1) + 1(6) = 8e^-$**

$-4e^-$

$-4e^-$

0



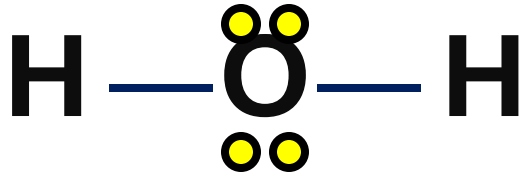
Did we use all the Ve^-?

Do all the atoms that need an octet have one?

Yesss, you have done good job!!!

Drawing Lewis Structures

H_2O



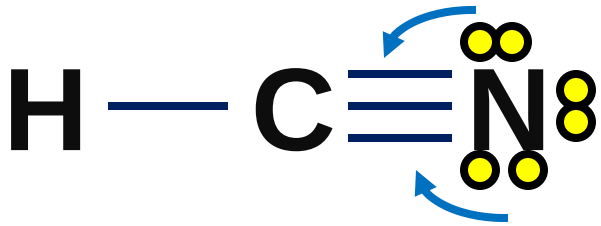
We have
2 lone e- pairs
2 bonding pairs

Drawing Lewis Structures

- **If (and only if) there are not enough e^- to give the central atom an octet, try multiple bonds.**

Use one (or more) unshared pairs of e^- to form double (or triple) bonds: HCN

Number of Ve^- : 1+ 4 + 5 = 10Ve^-



-4e^-

-6e^-

-0Ve^-

Oops Carbon does not have an octet…

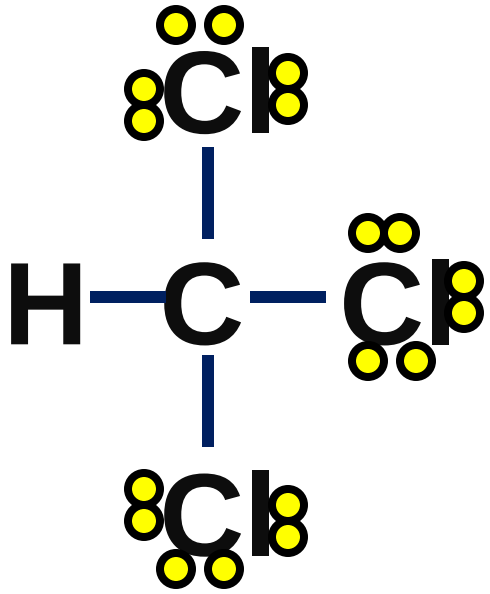
Now both nitrogen and carbon have an octet

Drawing Lewis Structures

Example: Draw the Lewis structure for $CHCl_3$

# of Ve^- = 4 + 1 + 3(7) = 26Ve^-

C = central atom



-8e^-

-18e^-

0Ve^-

We have used all the Ve- and every atom that needs and octet has one

Drawing Lewis Structures

Example: Draw the Lewis structure for PO_4^{3-}.

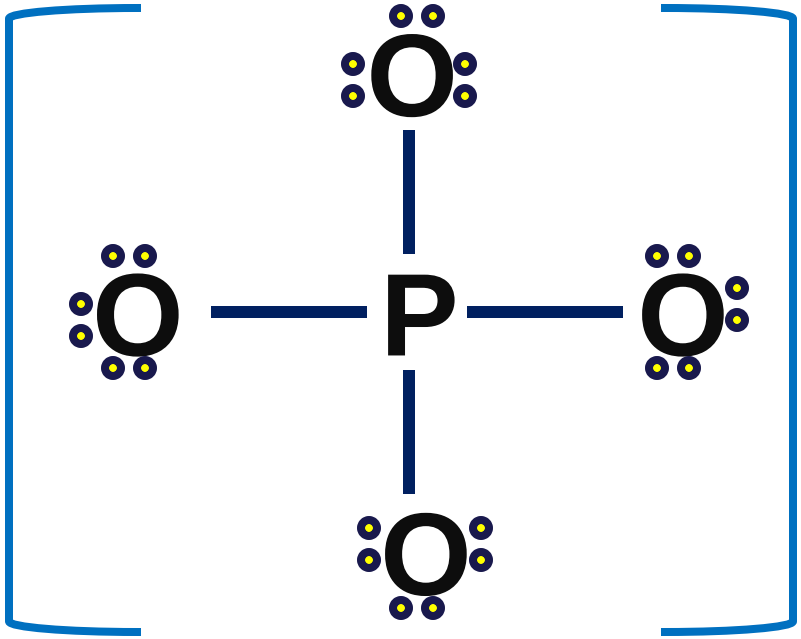
 # valence electrons = 5 + 4(6) + 3 = 32Ve$^-$

P = central atom

-8e$^-$

-24e$^-$

-0Ve$^-$



-3

Don't forget to show the charge of the ion, too.

Drawing Lewis Structure

With your partner write the steps for drawing Lewis structures. Note any special manipulations you may need to do to get all atoms an octet and use all your Ve^-.

1.

2.

3.

4.

Small Group Practice

In your lab groups please complete the Lewis structures of the following:

Carbon dioxide

Elemental iodine

CH_3Cl

Sulfate ion* **(remember the charge)**

Home Work

Read 322-323, #1-2 in text book

Bell Work19-Jan-2017

For the following compound and ions draw the Lewis structure using the four (4) steps:

1. Total number of Ve^-
2. Draw skeletal structure
3. Add e^- to outer elements
4. Add remaining e^- to central atoms, if you run out, use 2x or 3x bonds
5. Check that all Ve^- are used & that every atom that needs an octet has one, *add brackets w/ charge for ions, and draw all resonance structures.*

Cl_2 **CH_3Br**

SiO_2 **SO_4^{2-}**

Objective:

You will be able to draw resenance how to predict the molecular geometry and bond angles of simple compounds based on their Lewis Structure

EQ: What am I doing today for my future goals and how can keep on track.

Practice

Complete the following for SiO

#of Valence electrons :_____

# of lone pairs (electrons ••):_____

#of bonding pairs (—): _____

Structure:

Si O

Drawing Lewis Structures Your Turn

Draw the Lewis structure for PCl_3

Draw the Lewis structure for NO_2^-

Draw the Lewis structure for XeF_2

Drawing Lewis Structures
Ion practice

a) BH_2^-

b) SO_3^{2-}

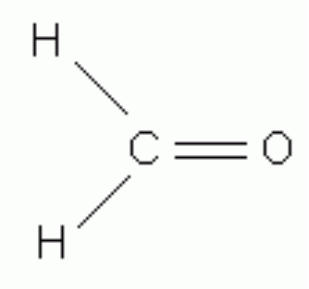
c) ClF_4^+ **(Cl gets more than an octet)**

d) ClO_3^-

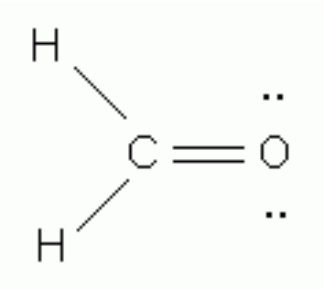
Drawing Lewis Structures
Ion practice

Which is the correct structure for CH_2O?

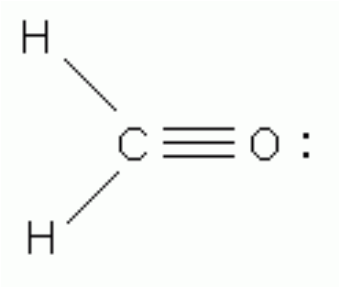
1



2



3



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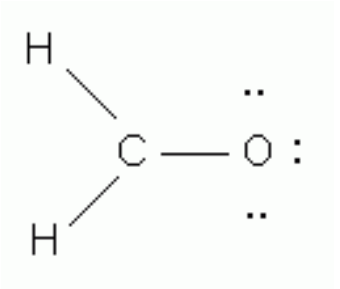
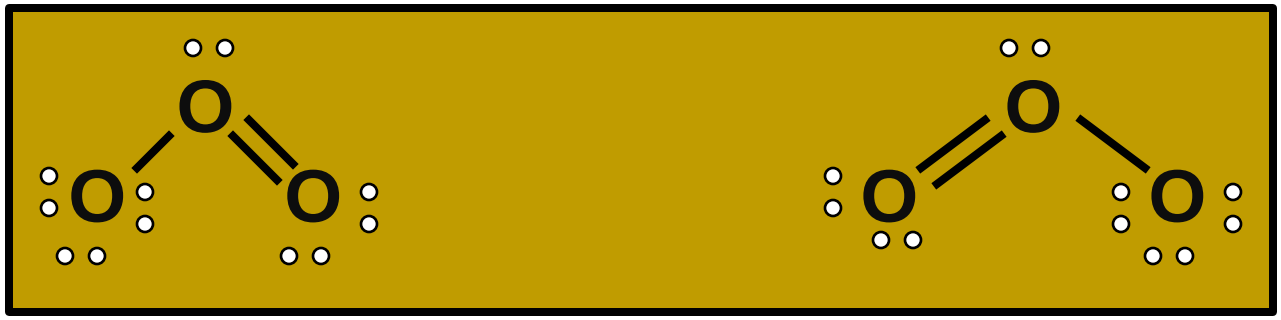


Drawing Lewis Structures

When writing the Lewis structure for ozone we could easily have put the double bond between the other two oxygens.

Ozone (O_3):



Bell Work 20-Jan-2017

For the following compound and ions draw the Lewis structure using the four (4) steps:

1. Total number of Ve^-
2. Draw skeletal structure
3. Add e^- to outer elements
4. Add remaining e^- to central atoms, if you run out, use 2x or 3x bonds
5. Check that all Ve^- are used & that every atom that needs an octet has one, add brackets w/ charge for ions, and draw all resonance structures.

CO_3^{2-}

How many " " are around the central atoms		
Central Atom	# of bonding regions	# of loan pairs

Use page 326-327 in text book to predict molecular geometry

Objective:

You will be able to predict the molecular geometry of simple compounds based on their Lewis Structure and text book chart

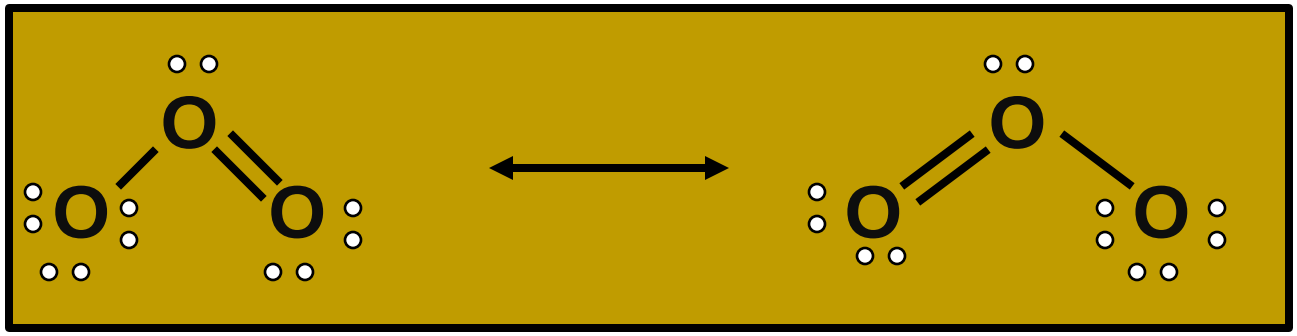
EQ: What am I doing today for my future goals and how can keep on track.

Drawing Lewis Structures

These two structures are equivalent except for the placement of electrons.

Resonance structures

Resonance structures for ozone:



Drawing Lewis Structures

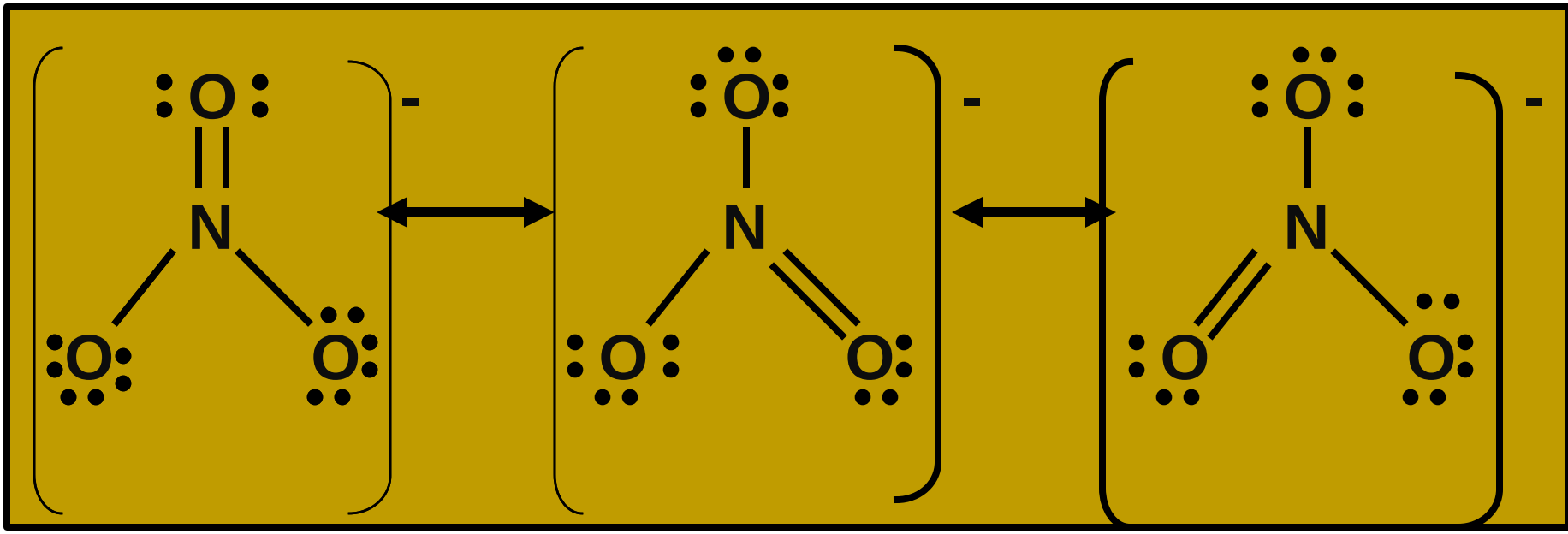
<u>Resonance structure:</u> one of a group of Lewis structures used to describe a molecule that cannot be accurately depicted using a single Lewis structure

NOTE: The real molecule is a "hybrid" or average of the resonance structures. It does not "flip" back and forth between the possible structures.

Drawing Lewis Structures

Example: Draw all possible resonance structures for NO_3^-.

 # valence electrons = 5 + 3(6) + 1 = 24



Home Work

Start/ Keep working of Science fair experimental design trial run or engineering designee prototyping, initial trials and prototypes need to be finished by 27 January 2017. You will have two (2) weeks to amend your experimental design/ procedures and complete all data collection.

Bell Work
23-Jan-2017

Draw all possible resonance structures (that follow the octet rule) for SO_2.

Bell Work
25-Jan-2017

What diatomic elements are missing?

H_2, O_2, Br_2,

Which of the diatomic elements has a double bond between its atoms?

Objective:

You will KNOW how to predict the molecular geometry and bond angles of simple compounds based on their Lewis Structure and identify polar compounds

EQ: What responsibilities do I have as an American to my country, community, family and self?

Review of Chemical Bonds

There are 3 forms of bonding:

ionic —complete *transfer* of 1 or more electrons from one atom to another (one loses, the other gains) forming oppositely charged ions that attract one another (metal and non-metal)

Covalent —some valence electrons *shared* between atoms (non-metal and non-metal)

Polar Covalent – uneven sharing of valence electrons between atoms (non-metal and non-metal)

The type of bond can *usually* be calculated by finding the difference in electronegativity of the two atoms that are going together.

Page 303 Table 12.1

1A	2A											3A	4A	5A	6A	7A
							H 2.1									
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2	3B	4B	5B	6B	7B	8B			1B	2B	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5
Cs 0.7	Ba 0.9	La 1.1	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2

<1.0 1.0–1.4 1.5–1.9 2.0–2.4 2.5–2.9 3.0–4.0

Figure 9.9 Electronegativity values for the elements according to Pauling. Trends for electronegativities are the opposite of the trends defining metallic character. Nonmetals have high values of electronegativity, the metalloids have intermediate values, and the metals have low values.

Electronegativity Difference

If the difference in electronegativities is between:

1.7 to 4.0: Ionic

0.3 to 1.7: Polar Covalent

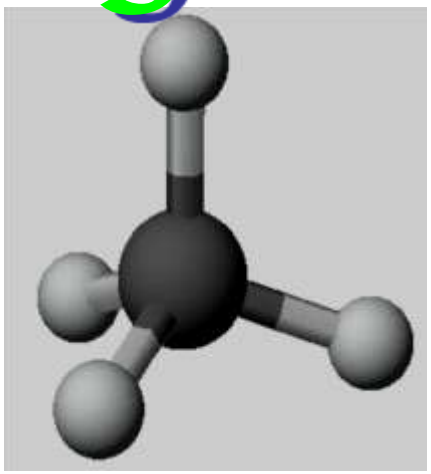
0.0 to 0.3: Non-Polar Covalent

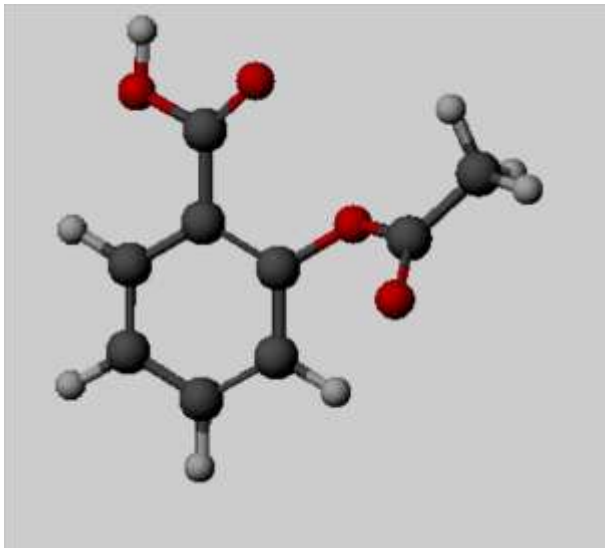
Example: NaCl

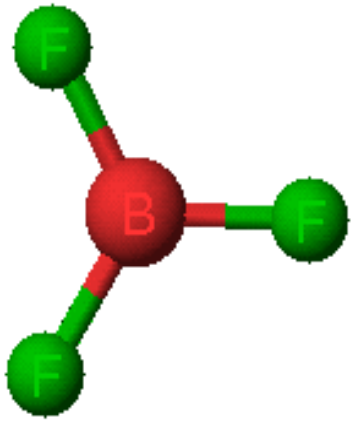
Na = 1.01, Cl = 2.83

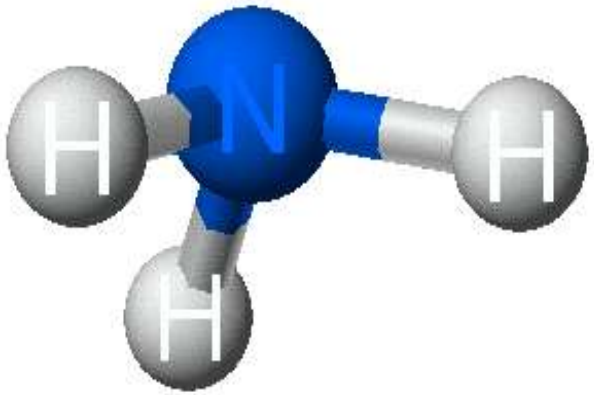
Difference is 1.82, so this is an ionic bond!

MOLECULAR GEOMETRY









MOLECULAR GEOMETRY

VSEPR

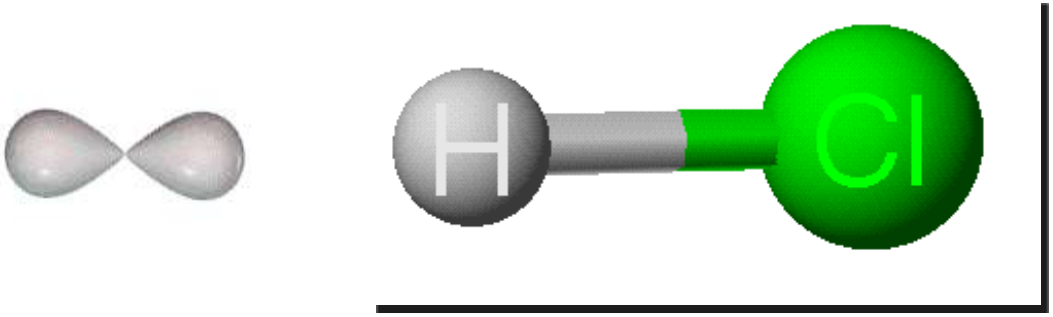
Valence Shell Electron Pair Repulsion theory.

Most important factor in determining geometry is relative repulsion between electron pairs.

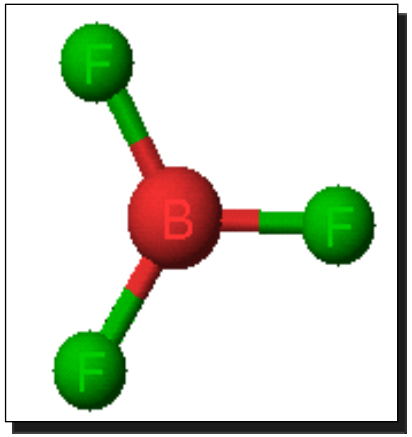
Molecule adopts the shape that minimizes the electron pair repulsions.

Some Common Geometries

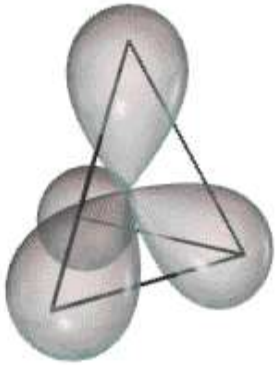
Linear

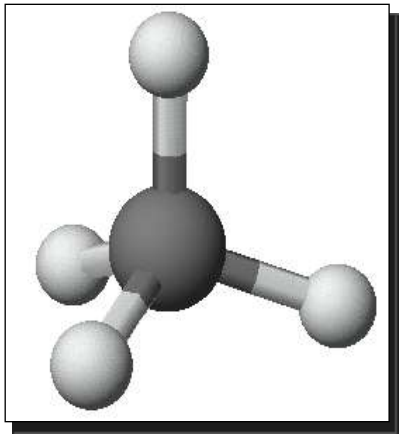


Trigonal Planar



Tetrahedral





VSEPR charts
Page 326-327 Table 13.1

Use the Lewis structure to determine the geometry of the molecule

e^- arrangement establishes the bond angles

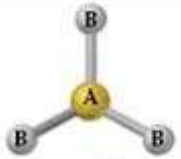
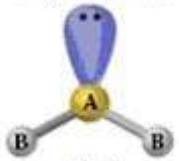
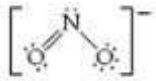
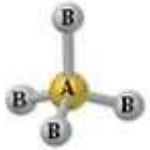
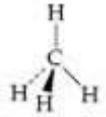
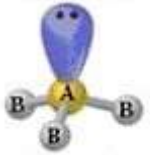
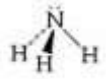
Molecule takes the shape of that portion of the e^- arrangement

Charts look at the CENTRAL atom for all data!

Think REGIONS OF ELECTRON DENSITY rather than bonds (for instance, a double bond would only be 1 region)

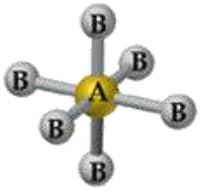
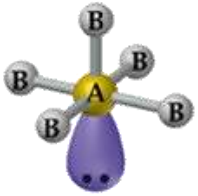
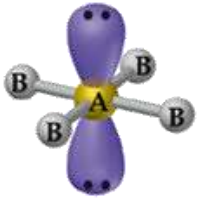
Know these five shapes!

TABLE 9.2 Electron-Domain Geometries and Molecular Shapes for Molecules with Two, Three, and Four Electron Domains Around the Central Atom

Number of Electron Domains	Electron-Domain Geometry	Bonding Domains	Nonbonding Domains	Molecular Geometry	Example
2	 Linear	2	0	 Linear	
3	 Trigonal planar	3	0	 Trigonal planar	
		2	1	 Bent	
4	 Tetrahedral	4	0	 Tetrahedral	
		3	1	 Trigonal pyramidal	
		2	2	 Bent	

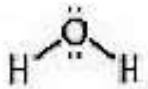
Other VSEPR charts

TABLE 9.3 Electron-Domain Geometries and Molecular Shapes for Molecules with Five and Six Electron Domains Around the Central Atom

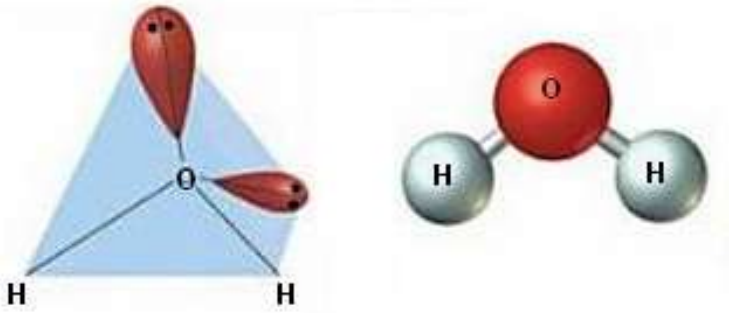
Total Electron Domains	Electron-Domain Geometry	Bonding Domains	Nonbonding Domains	Molecular Geometry	Example
6	 Octahedral	6	0	 Octahedral	SF_6
		5	1	 Square pyramidal	BrF_5
		4	2	 Square planar	XeF_4

Structure Determination by VSEPR

Water, H_2O



Lewis structure of H_2O

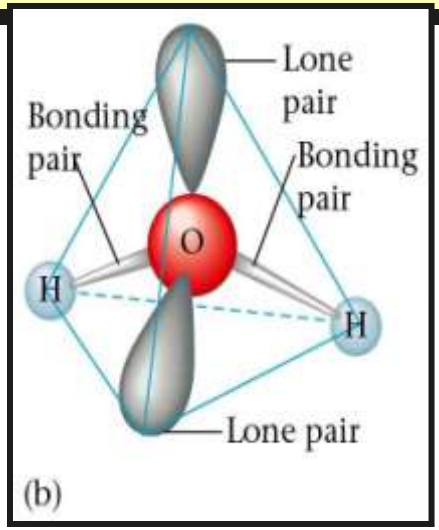


Molecular geometry of H_2O

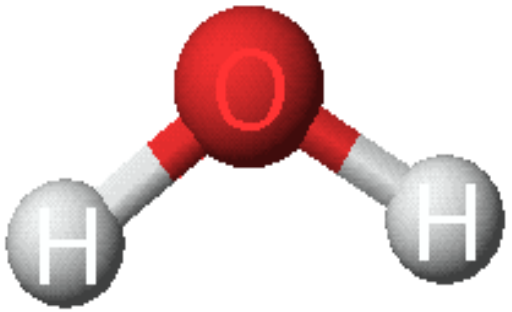
2 bond pairs

2 lone pairs

The electron pair geometry is TETRAHEDRAL

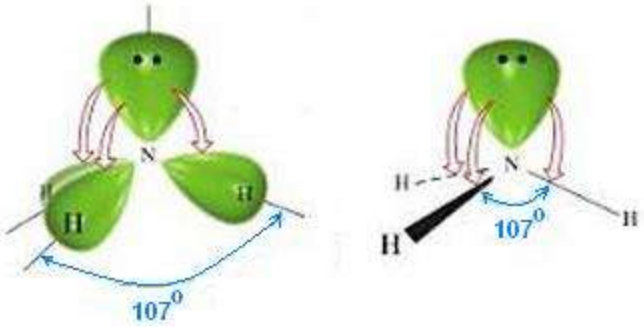


The molecular geometry is BENT.



Structure Determination by VSEPR

Ammonia, NH_3
The electron pair geometry is tetrahedral.

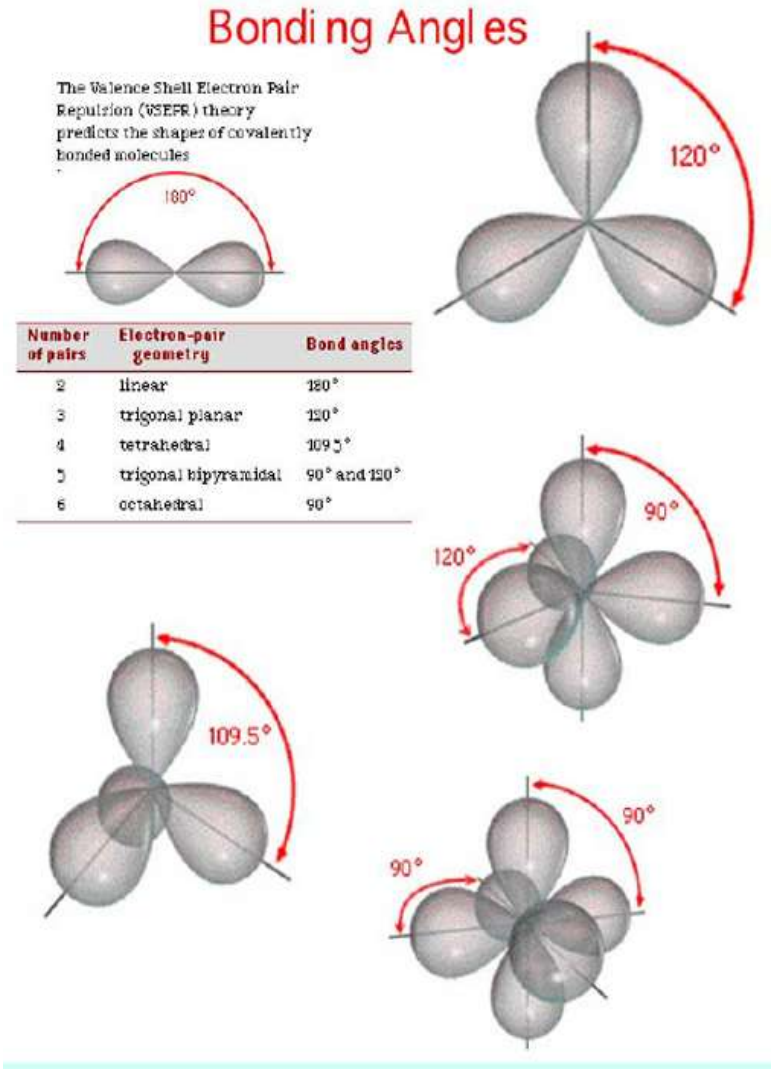


Repulsion of lone pair and bond pair

The MOLECULAR GEOMETRY — the positions of the atoms — is TRIGONAL PYRAMID.

Bond Angles (Geometry!!)

Since the atoms must arrange themselves in a way to maximize the space between them the various shapes coincide with specific angles between atoms



Number of pairs	Electron-pair geometry	Bond angles
2	linear	180°
3	trigonal planar	120°
4	tetrahedral	109.5°
5	trigonal bipyramidal	90° and 120°
6	octahedral	90°

Lets Try One

BeH_2

Lewis Structure	Sketch e- & bonding regions	Molecular Geometry	Bond Angles

Lets Try Another

H_2CS

Lewis Structure	Sketch e- & bonding regions	Molecular Geometry	Bond Angles

Lets Try Another

H_2S

Lewis Structure	Sketch e- & bonding regions	Molecular Geometry	Bond Angles

Drawing Lewis Structures

Example: Draw all possible resonance structures for H_2SO_4.
Hint S-O-H, all oxygen are connected to sulfur

Drawing Lewis Structures

Not all compounds follow the octet rule!

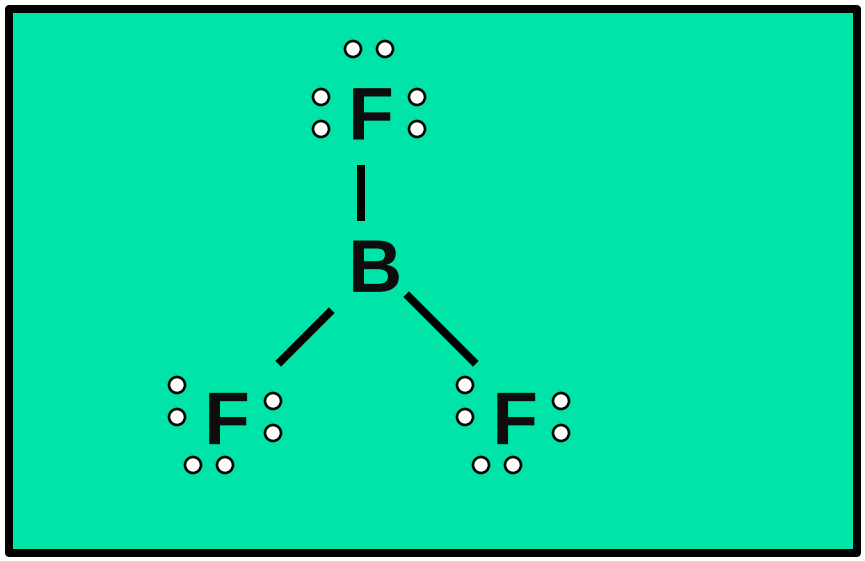
Exceptions to the octet rule:

Molecules with an odd # of electrons
NO (5 + 6 = 11 electrons)

Drawing Lewis Structures

Exceptions to the octet rule:

Molecules in which an atom has less than an octet.

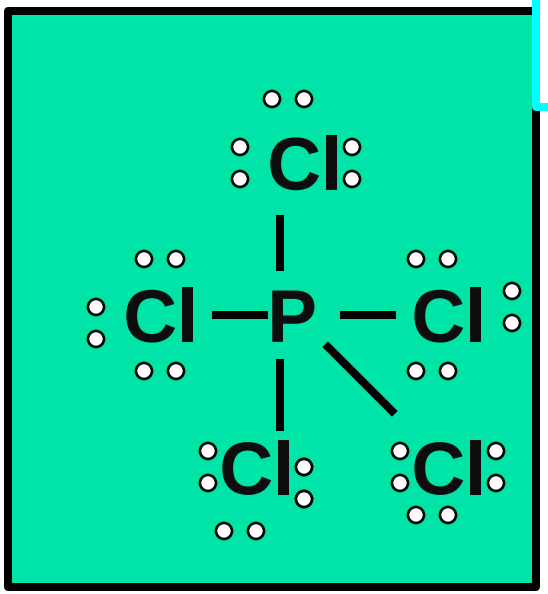


Drawing Lewis Structures

Exceptions to the octet rule:

Molecules in which an atom has more than an octet. Central atom needs to be "$3p^x$" or higher because…

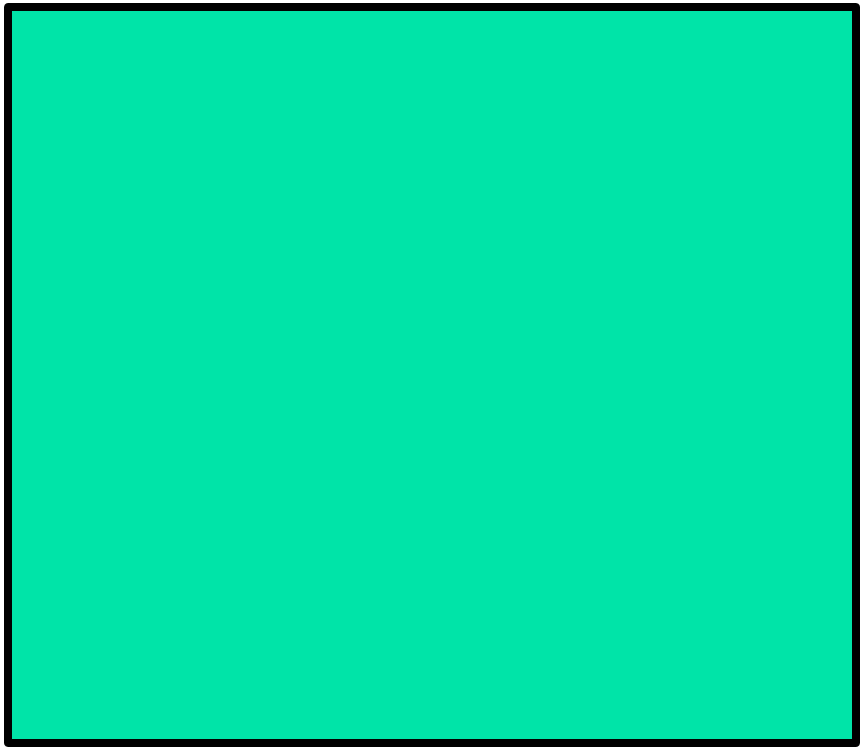
of the 3d orbital!



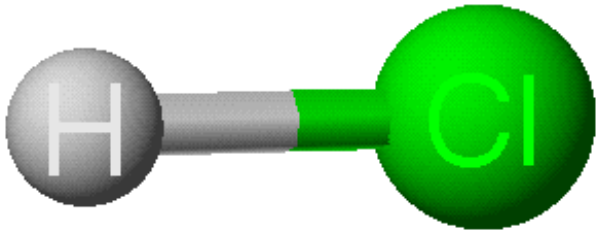
Drawing Lewis Structures

Example: Draw the Lewis structure for

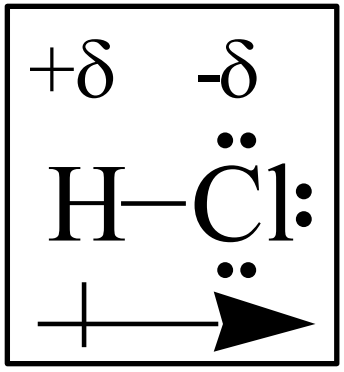
ClF_3



Bond Polarity



HCl is POLAR because it has a positive end and a negative end. (difference in electronegativity)



Cl has a greater share in bonding electrons than does H.

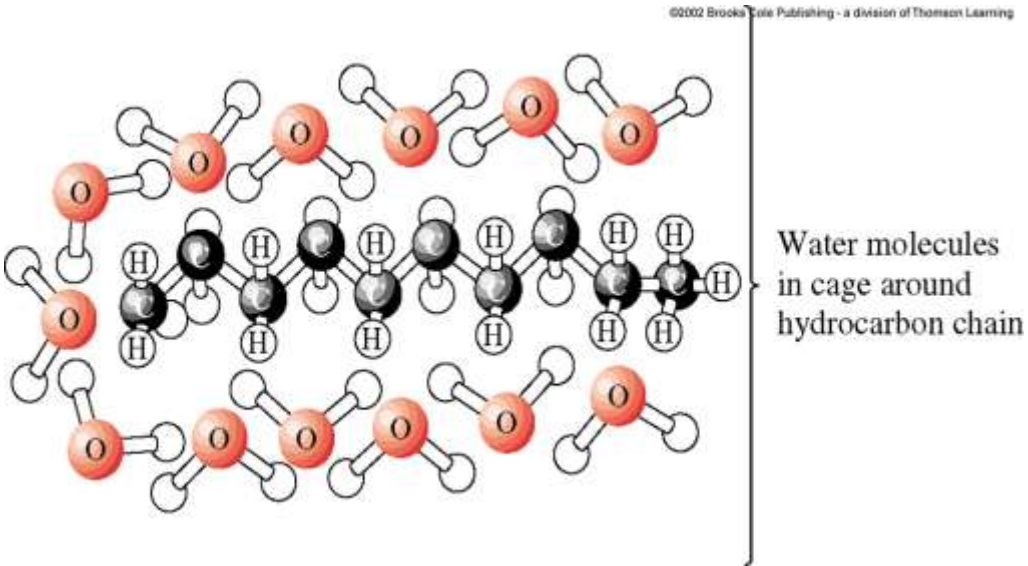
http://www.youtube.com/watch?v=LKAjTE7B2x0&feature=related

Cl has slight negative charge (-δ) and H has slight positive charge (+ δ)

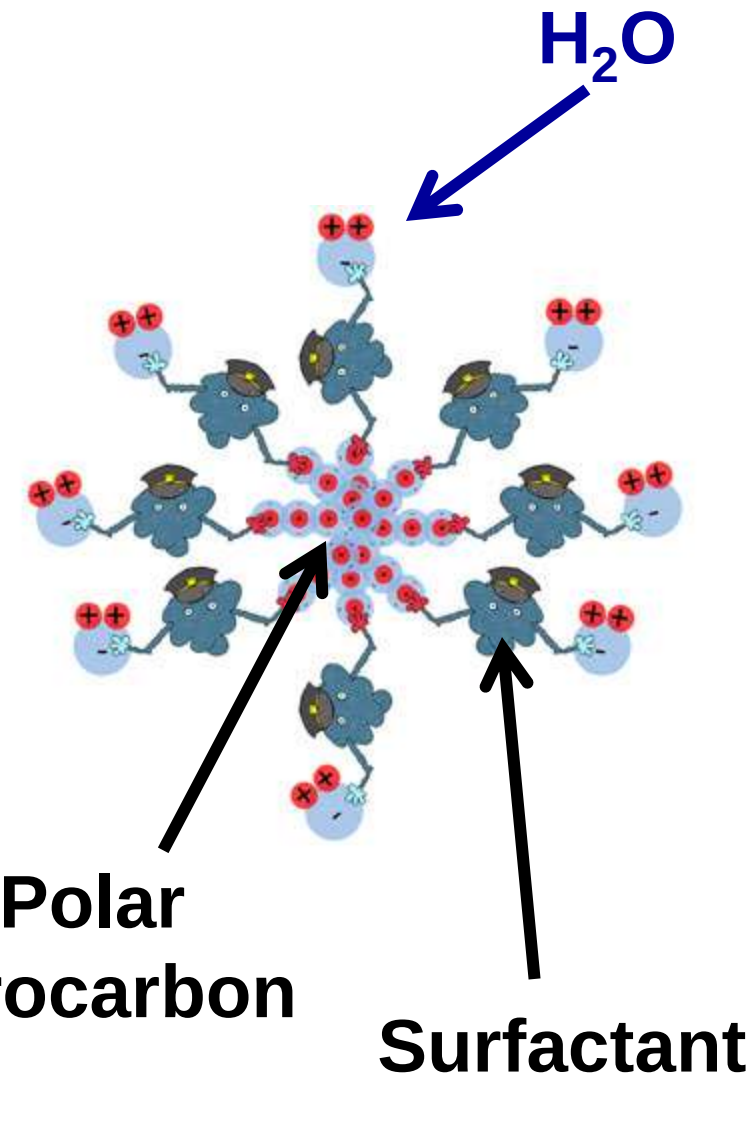
Bond Polarity

This is why oil and water will not mix! Oil is nonpolar, and water is polar.

The two will repel each other, and so you can not dissolve one in the other



Polarity differences and Surfactants



Molecular Structure and VSEPR

On your own or in pairs you will: build 12 compounds
Draw Lewis Structures
Predict Molecular Geometry
Predict Bond angles

Bond Polarity

“Like Dissolves Like”

Polar dissolves

Polar

Nonpolar dissolves

Nonpolar

Violations of the Octet Rule
Pre-AP

Usually occurs with B and elements of higher periods. Common exceptions are: Be, B, P, S, and Xe.

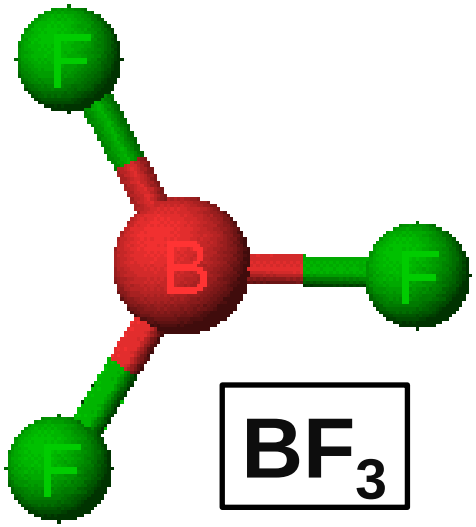
Be: 4

B: 6

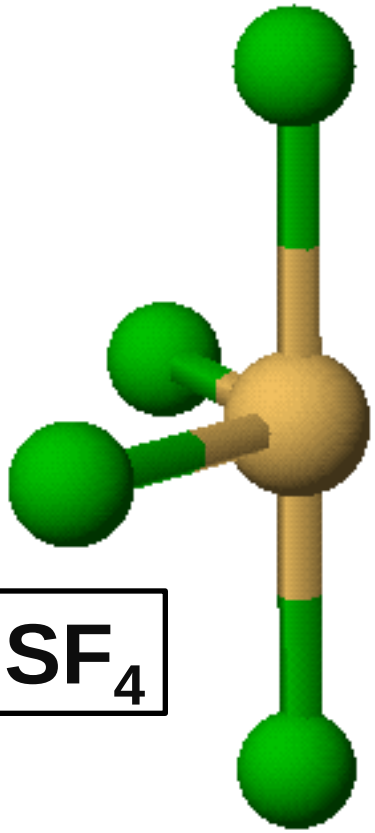
P: 8 OR 10

S: 8, 10, OR 12

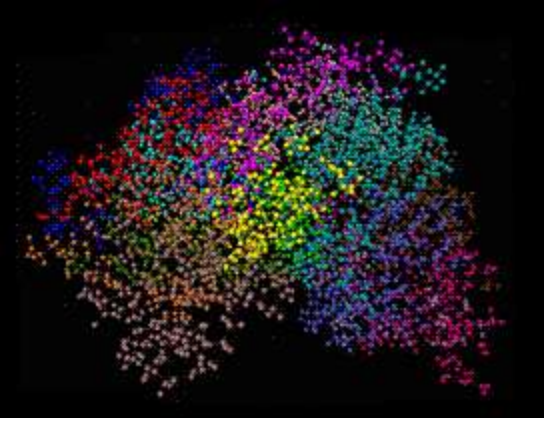
Xe: 8, 10, OR 12



BF_3



SF_4



Molecular Modeling

You will make a 3D paper model of a common molecule representing its molecular geometry.

This may be colored if you would like and used at home over winter break to share and spread the wonders of chemistry